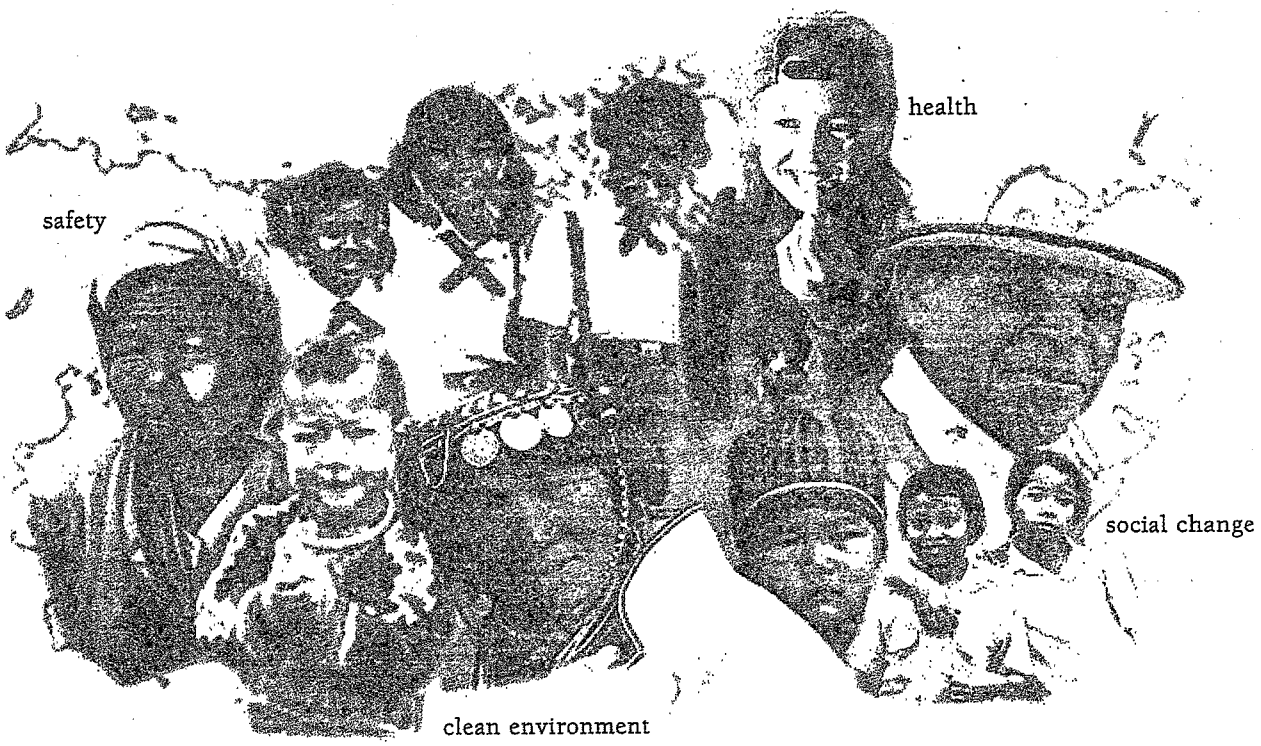
Solid Waste Management: A Local Challenge With Global Impacts



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The following descriptions introduce and define the main activities classified under ISWM.

WASTE PREVENTION Waste prevention—often called source reduction—means reducing waste by not producing it. Examples of waste prevention would include purchasing durable, long-lasting goods and seeking products and packaging that are as free of toxic substances as possible. It can be as simple as switching from disposable to reusable products, or as complex as redesigning a product to use fewer raw materials or to last longer. Because waste prevention actually avoids waste generation, it is the preferred waste management activity. Overall, waste prevention conserves resources, protects the environment, and prevents the formation of greenhouse gases.

RECYCLING Recycling makes use of materials that otherwise would become waste by turning them into valuable resources. Recycling helps reduce greenhouse gas emissions, in part, by diverting waste from landfills. In some countries, a great deal of recycling occurs before the waste reaches the landfill. Scrap dealers buy directly from households and businesses, wastepickers or scavengers collect materials from waste bins, and waste collectors separate materials that can be sold as they load their trucks. Governments can build on these practices by providing support to organize and improve recycling efforts.

COMPOSTING Another form of recycling is composting—the controlled aerobic biological decomposition of organic matter, such as food scraps and plant matter, into humus, a soil-like material. Compost acts as a natural fertilizer by providing nutrients to the soil, increasing beneficial soil organisms, and suppressing certain plant diseases, thereby reducing the need for chemical fertilizers and pesticides in landscaping and agricultural activities. Organic materials often comprise a large portion of the solid waste stream, particularly in communities that rely heavily on tourism. Composting can be particularly helpful to communities managing their waste and thus reducing greenhouse gas emissions.

COMBUSTION Combustion is the controlled burning of waste in a designated facility to reduce its volume and, in some cases, to generate electricity. Combustion is an ISWM option for wastes that cannot be recycled or composted, and is sometimes selected by communities where landfill space is limited. While the combustion process can generate toxic air emissions, these can be controlled by installing control equipment such as acid gas scrubbers and fabric filters in combustors. Combustion of solid waste can help reduce amount of waste going to landfills. It also can reduce reliance on coal, one of the fossil fuels that produces greenhouse gases when burned.

LANDFILLING Uncontrolled dumping of waste can contaminate groundwater and soil, attract disease-carrying rats and insects, and even cause fires. Properly designed, constructed, and managed landfills provide a safe alternative to uncontrolled dumping. For example, to protect groundwater from the liquid that collects in landfills (leachate), a properly designed landfill has an earthen or synthetic liner. As waste decomposes, it emits methane, a greenhouse gas that can also cause fires. To prevent fires, a properly designed landfill should have a way to vent, burn, or collect methane. Landfill operators can also recover this methane—thereby reducing emissions—and generate electricity from the captured gas.

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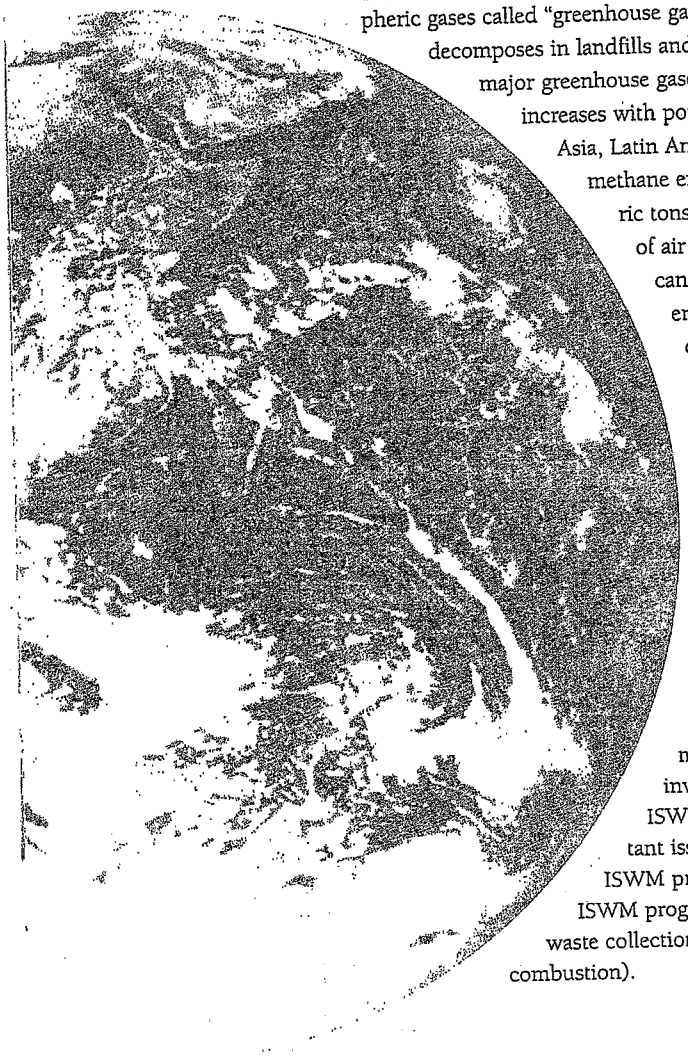
SOLID WASTE MANAGEMENT AND CLIMATE CHANGE

BASURA, GARBAGE, GOMI, ORDURES, AFVAL, SPAZZATURA—whatever people call it, solid waste is a problem that must be properly managed. While it is generally understood that proper waste management helps protect human health and the environment and preserve natural resources, many do not realize that solid waste also impacts climate change. The manufacture, distribution, and use of products—as well as the disposal of the resulting waste—all result in emissions of atmospheric gases called "greenhouse gases" that affect the Earth's climate. When organic waste decomposes in landfills and uncontrolled dumps, it produces methane, one of the major greenhouse gases contributing to climate change. Waste generation increases with population expansion and industrialization. Countries in Asia, Latin America, and Africa account for nearly 40 percent of annual methane emissions from landfills, which is equal to 37 million metric tons of carbon dioxide equivalent ($MTCO_2e$) or the amount of air emissions from more than 102 million automobiles. You can reduce greenhouse gas emissions, however, through proper solid waste management (for a more detailed explanation of the relationship between climate change and solid waste, see the *What is Integrated Solid Waste Management?* fact sheet).



Solid waste should be managed through a number of activities—waste prevention, recycling, composting, controlled burning, or landfilling. Using a combination of these activities together in a way that best protects your community and the local environment is referred to as integrated solid waste management (ISWM). An ISWM program can help reduce greenhouse gas emissions and slow the effects of climate change. This folder and its accompanying fact sheets are designed for government officials, nongovernmental organizations, and others involved in planning and communicating the benefits of ISWM programs. The fact sheets will introduce you to important issues you will need to address in planning a successful ISWM program. These fact sheets also assist you in planning an ISWM program by providing guidelines for recycling and composting, waste collection and transport, and waste disposal (landfilling and combustion).

U.S. ENVIRONMENTAL PROTECTION AGENCY

<www.epa.gov>

In the United States, the Environmental Protection Agency (EPA) is the national agency that works to protect human health and the natural environment. EPA establishes and enforces national environmental protection standards, conducts research on environmental problems, and assists other organizations in protecting the environment through grants, technical assistance, and other programs.

EPA's **Office of Solid Waste (<www.epa.gov/osw>)** promotes and supports residential, commercial, and governmental efforts to reduce waste, prevents future waste disposal problems by establishing effective standards, and cleans up areas where wastes may have spilled, leaked, or been improperly disposed of. In addition, OSW's Climate and Waste Program works to prevent climate change by informing the public of and studying the link between solid waste and greenhouse gas emissions. To support efforts to reduce greenhouse gases globally, the Climate and Waste Program provides outreach and technical assistance to other countries.

EPA's **Office of International Activities (<www.epa.gov/oia>)** manages the Agency's involvement in international policies and programs that cut across EPA's offices and regions. More generally, OIA also provides leadership and coordination at EPA and acts as the focal point on a variety of international environmental matters.

What Is Integrated Solid Waste Management?

This fact sheet provides an overview of options for managing solid waste, identifies the important issues you should consider when planning for solid waste management, and describes the link between solid waste management and climate change. The other fact sheets in this series include:

- How To Establish Recycling and Composting Programs
- What Are the Components of Waste Collection and Transport?
- What Are the Options for Waste Disposal?

Why Is Solid Waste Management a Challenge?

Waste generation increases with population expansion and economic development. Improperly managed solid waste poses a risk to human health and the environment. Uncontrolled dumping and improper waste handling causes a variety of problems, including contaminating water, attracting insects and rodents, and increasing flooding due to blocked drainage canals or gullies. In addition, it may result in safety hazards from fires or explosions. Improper waste management also increases greenhouse gas (GHG) emissions, which contribute to climate change (for more information on climate change and the impacts from solid waste, see next page). Planning for and implementing a comprehensive program for waste collection, transport, and disposal—along with activities to prevent or recycle waste—can eliminate these problems.

What Is Integrated Solid Waste Management?

Integrated Solid Waste Management (ISWM) is a comprehensive waste prevention, recycling, composting, and disposal program. An effective ISWM system considers how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment. ISWM involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions. The major ISWM activities are waste prevention, recycling and composting, and combustion and disposal in properly designed, constructed, and managed landfills (see Figure 1). Each of these activities requires careful planning, financing, collection, and transport, all of which are discussed in this and the other fact sheets.

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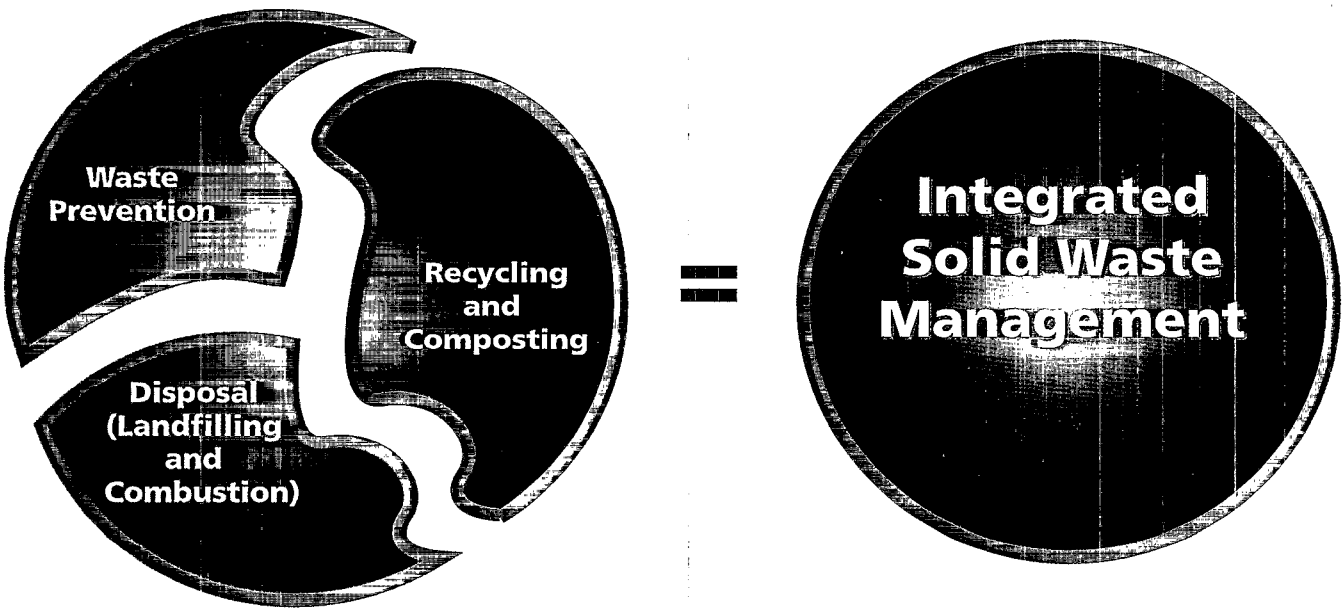
- **Waste Prevention.** Waste prevention—also called "source reduction"—seeks to prevent waste from being generated. Waste prevention strategies include using less packaging, designing products to last longer, and reusing products and materials. Waste prevention helps reduce handling, treatment, and disposal costs and ultimately reduces the generation of methane.
- **Recycling and Composting.** Recycling is a process that involves collecting, reprocessing, and/or recovering certain waste materials (e.g., glass, metal, plastics, paper) to make new materials or products. Some recycled organic materials are rich in nutrients and can be used to improve soils. The conversion of waste materials into soil additives is called composting. Recycling and composting generate many environmental and economic benefits. For example, they create jobs and income, supply valuable raw materials to industry, produce soil-enhancing compost, and reduce greenhouse gas emissions and the number of landfills and combustion facilities.
- **Disposal (landfilling and combustion).** These activities are used to manage waste that cannot be prevented or recycled. One way to dispose of waste is to place it in properly designed, constructed, and managed landfills, where it is safely contained. Another way to handle this waste is through combustion. Combustion is the controlled burning of waste, which helps reduce its volume. If the technology is available, properly designed, constructed, and managed landfills can be used to generate energy by recovering methane. Similarly, combustion facilities produce steam and water as a byproduct that can be used to generate energy.

Developing a Plan for Integrated Solid Waste Management

Planning is the first step in designing or improving a waste management system. Waste management planners should, for example, take into consideration institutional, social, financial, economic, technical, and environmental factors (see Table 1). These factors vary from place to place. Based on these factors, each community has the challenge of selecting the combination of waste management activities that best suits its needs.

Because integrated solid waste management involves both short- and long-term choices, it is critical to

Figure 1—Integrated Solid Waste Management



What Is the Relationship Between Climate Change and Solid Waste?

WHAT IS THE GREENHOUSE EFFECT?

The Earth's atmosphere contains many types of gases, including those known as "greenhouse gases," which hold in the sun's warmth (see text box). Scientists call this naturally occurring phenomenon the "greenhouse effect." Greenhouse gases help regulate global temperatures. Certain human activities such as burning fossil fuels and dumping solid waste, however, produce additional greenhouse gases and upset the natural balance by raising global temperatures.

WHY SHOULD I BE CONCERNED ABOUT GREENHOUSE GAS EMISSIONS?

Greenhouse gas emissions are slowly changing the Earth's climate. The Earth has already become slightly warmer in the past 100 years and will continue to become warmer. This could cause serious human health and environmental consequences because a warmer climate may cause more frequent and severe heat waves, damage agriculture, and cause droughts in some places and floods in others.

HOW DOES SOLID WASTE IMPACT CLIMATE CHANGE?

Even before a material or product becomes solid waste, it goes through a long cycle that involves removing and processing raw materials, manufacturing the product, transporting the materials and products to markets, and using energy to operate the product. Each of these activities has the potential to generate greenhouse gas emissions through one or more of the following means:

- **Energy consumption.** Extracting and processing raw materials, manufacturing products, and transporting materials and products to markets all generate greenhouse gas emissions by consuming energy from fossil fuels.
- **Methane emissions.** When organic waste decomposes in landfills, it generates methane, a greenhouse gas.
- **Carbon storage.** Trees absorb carbon dioxide, a greenhouse gas, from the air and store it in wood through carbon sequestration. Waste prevention and recycling of wood and paper products allow more trees to remain standing in the forest, where they can continue to remove carbon dioxide from the air, which helps minimize climate change impacts.

Different wastes and waste management activities have varying impacts on energy consumption, methane emissions, and carbon storage. For example, recycling reduces greenhouse gas emissions by preventing methane emissions from landfills or open dumps and by preventing the consumption of energy for extracting and processing raw materials. Communities that are looking for ways to help prevent climate change can start by implementing an integrated solid waste management program.

WHAT ARE GREENHOUSE GASES?

Some greenhouse gases—such as water vapor, carbon dioxide, methane, nitrous oxide, and ozone—occur naturally in the atmosphere, while others result from human activities.

Carbon dioxide is released to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), and wood and wood products are burned. **Methane** is emitted during the production and transport of coal, natural gas, and oil; the decomposition of organic wastes in municipal solid waste landfills; and by livestock. **Nitrous oxide** is emitted during agricultural and industrial activities, as well as during the combustion of solid waste and fossil fuels.

Each greenhouse gas differs in its ability to trap heat in the atmosphere. Methane traps over 21 times more heat than carbon dioxide, and nitrous oxide absorbs 310 times more than carbon dioxide. The higher the heat trapping potential of the gas, the greater the impact on climate change. Efforts to decrease emissions of these gases help reduce climate change impacts.

operations of solid waste management activities. Each level of government may have responsibility in your ISWM plan: national governments typically set standards for solid waste management; the state, provincial, or regional governments may help monitor and enforce these standards; and local governments often play the primary role of managing solid waste activities on a daily basis. All levels may also provide funding for solid waste management activities. Two primary costs must be considered in any waste management system: initial capital costs (to purchase equipment or construct new facilities) and ongoing operations and maintenance costs. These costs can be funded in a number of ways including private equity, government loans, local taxes, or users fees.

Implementing an Integrated Solid Waste Management Plan

Once you have developed and written your solid waste management plan, you can begin to implement the various combinations of waste management activities. Implementing an ISWM plan is an ongoing process, so expect to make adjustments to the plan along the way. Always evaluate system inefficiencies and make adjustments to improve or expand solid waste management services. Figure 2 (on back page) illustrates how you can implement an ISWM plan. Some of these questions may have been answered during development of the ISWM plan, but it is important to see how they fit into the comprehensive implementation process. Equally important, it emphasizes the need to provide public education and keep the community involved in every step of the process.

Be flexible and creative when implementing your plan. If you are not making progress in a certain area, be prepared to reevaluate components of your plan. It is helpful to keep in mind the ultimate goal of ISWM: to improve human health and protect the environment.

DEFINITIONS

Combustion: Refers to controlled burning of waste with environmental control technology to reduce the waste volume and generate energy.

Composting: The controlled aerobic biological decomposition of organic matter, such as food scraps and plant matter, into humus, a soil-like material.

Aerobic: Decomposition process in the presence of oxygen (see "composting").

Anaerobic: Decomposition process in the absence of oxygen (see "methane").

Landfill: Disposal site for nonhazardous solid wastes. The waste is spread into layers, compacted to reduce its volume, and covered by material such as clay or soil, which is applied at the end of each operating day.

Methane: Gas generated when wastes in a landfill decompose anaerobically; comprises approximately 50 percent of the gases emitted from landfills.

Recycling: The act of collecting, reprocessing, and/or recovering certain waste materials to make new materials or products

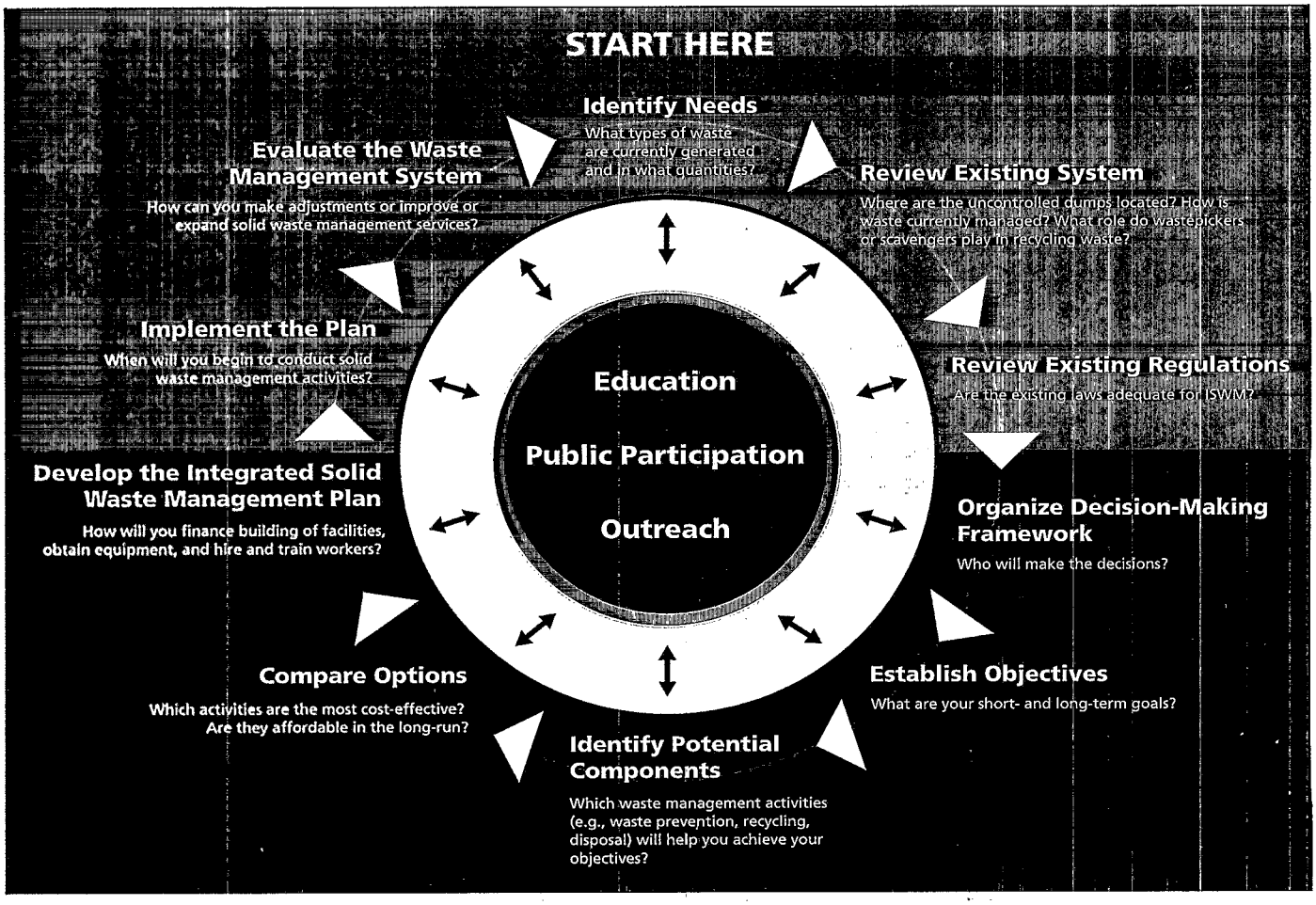
set achievable goals. While developing your ISWM plan, you should identify goals or objectives (e.g., protect human health, protect water supplies, eliminate open dumping, increase recycling or composting). The ISWM plan will help guide you through the implementation process. Do not neglect to ask for the community's input in developing your plan, so as to ensure an informed public and to increase public acceptance.

Government plays an important role in developing and enforcing waste management standards, providing funding, and managing day-to-day

Table 1 - Important Questions to Consider and Steps to Take When Developing an Integrated Solid Waste Management Plan

FACTORS	QUESTIONS TO CONSIDER	STEPS TO TAKE
Institutional (laws and processes)	**Are existing laws and policies adequate to allow the government to properly implement ISWM?**	▪ Establish a national policy and pass laws on solid waste management standards and practices. ▪ Identify the roles and responsibilities of each level of government. ▪ Ensure the local government has the authority and resources to implement an ISWM plan.
Social (local customs and religious practices, public education)	**What types of waste does your community generate and how it is managed?**	▪ Encourage citizen participation in all phases of waste management planning to help gain community awareness, input, and acceptance.
Financial (funding)	**Where will you go to get funds for creating a solid waste management system?**	▪ Identify sources that can provide funding for solid waste management, including general revenues or user fees, the private sector, and government or international agency grants and loans.
Economic (costs and job creation)	**What will it cost to implement various waste management activities?**	▪ Calculate the initial capital investment requirements and long-term operating and maintenance costs associated with the various waste management activities. ▪ Evaluate the public's ability and willingness to pay. ▪ Evaluate activities based on effectiveness in handling waste and potential for job creation.
Technical (location and equipment)	**Where will you build collection and disposal facilities and what equipment will you need?**	▪ Include geological factors, transport distances, and projected waste generation in siting and design considerations. ▪ Determine what equipment and training will be necessary to perform the waste management tasks. (See *How To Establish Recycling and Composting Programs, What Are the Components of Waste Collection and Transport?*, and *What Are the Options for Waste Disposal?* fact sheets.)
Environmental (natural resources and human health)	**Will solid waste management activities (e.g., landfilling or combustion) affect the environment?**	▪ Establish procedures to verify the protection of groundwater and drinking water. ▪ Monitor compliance with the national standards to ensure human health risks are minimized.

Figure 2—Comprehensive Integrated Solid Waste Management Planning Process



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How To Establish Recycling and Composting Programs

In many countries, recycling occurs informally at landfills, uncontrolled dumps, and on streets. Scavengers or wastepickers often collect materials for reuse or sale without any organization, supervision, or regulation. While scavenging or wastepicking can be very effective at reducing the amount of plastic, glass, metal, and paper ultimately requiring disposal, pursuing these activities can be harmful to worker health. Incorporating scavengers or wastepickers into organized or formal recycling programs can improve the quality of their working conditions and the local environment. Composting can also improve local economies and the environment—by turning organic waste, which is a large portion of many city waste streams, into a marketable product for urban and agricultural uses. Together, recycling and composting can provide income, significantly reduce waste, and decrease greenhouse gas emissions. This fact sheet describes the benefits of formal recycling and composting activities and provides steps on how you can incorporate scavenging or wastepicking into formal recycling and composting programs. At the end of this fact sheet, a case study from Brazil shows how businesses organized scavengers and wastepickers into successful recycling cooperatives.

What Are the Benefits of Formal Recycling and Composting Programs?

Recycling and composting activities, if organized properly by the local government, can generate many environmental and economic benefits. For example, it can create jobs and income, supply valuable raw materials to industry, produce soil-enhancing compost for agriculture, reduce the need to site or build more landfills and combustors, and prevent greenhouse gas emissions. An organized approach to recycling and composting can also have many benefits for your community. Involving scavengers or wastepickers in formal recycling activities can empower them, increase their income and reputation, and improve their quality of life, health, and safety.

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How Do I Start a Formal Recycling or Composting Program?

Establishing and managing formal recycling and composting programs requires significant local government time and resource investments. However, these investments can save money in the long term by allowing governments to maximize existing recycling and composting activities before making significant investments in collecting and transporting waste. To successfully implement formal recycling or composting programs, governments will need to consider social, financial, institutional, and regulatory issues. The following steps outline one possible approach for implementing a program.

Step 1. Plan and set goals. Set flexible goals and plans for your recycling and composting programs. As you follow each of the steps and learn more about the community's needs, adjust the plans to incorporate this information.

Step 2. Study the complete waste management system.

- **Evaluate the waste stream.** What types and amounts of waste are generated and by whom?
- **Identify existing activities.** Local governments should determine all waste recycling practices, including existing informal practices such as scavenging or wastepicking, in addition to existing recycling groups such as cooperatives and micro-enterprises, which are usually formed under the supervision of nongovernmental organizations (NGOs). This information will help community planners consider the recycling sector's requirements when they design an improved solid waste management system. Academic institutions and NGOs might be able to help perform surveys or other studies to gather these critical data.
- **Determine possible markets or buyers.** Who will purchase the materials?

Step 3. Work with the community.

- **Identify and meet with informal recycling groups, NGOs, and homeowners in cities.** The local government should select a coordinator to manage and work with wastepicking groups. The coordinator should first identify the various groups or individuals active in recycling or composting, and then meet with leaders within those groups to discuss local issues. If more than one recycling or composting group serves the community, the decision-makers should coordinate these groups' activities by assigning specific service locations to each group and setting guidelines for the types of waste they can recycle (e.g., paper, metals, glass, food). Involving the local government in these activities could help provide stability for the scavengers' or wastepickers' work and improve their quality of life.
- **Incorporate scavengers and wastepickers.** The local government should discuss and determine how existing scavenging or wastepicking activities and groups, such as cooperatives and micro-enterprises, could be incorporated into a formal waste management system. Emphasis should be placed on the improved economic, health, and safety benefits scavengers and wastepickers may experience under a more organized system.

Step 4. Create a designated recycling or composting area. The local government should designate areas within a waste disposal facility where sorting, recycling, and composting can occur. These areas can be fixed or moveable to meet the scavengers' or wastepickers' needs (see text box). Any recycling or composting that is being done at the landfill should be located away from the working surface of the landfill (i.e., where waste is being compacted and covered) to protect the health and safety of scavengers or wastepickers. The local government should determine what additional equipment might be necessary for a program and how the equipment will be provided.

Step 5. Develop operation standards. The local government should develop standard operating procedures for the scavengers or wastepickers. Standard operating procedures increase efficiency and help improve health and safety. Determining a time of day for groups to access a site is an important consideration. Requirements such as use of safety equipment (e.g., gloves or masks) and worker identification (e.g., uniforms or badges) can also be included in standard operating procedures.

Step 6. Determine who is responsible for selling the recyclables or composted material. The government should determine whether it will be involved in the sale of recyclables and compost, or if the landfill owner, workers, or cooperatives will interact with the buyers. The governing agency also should establish an agreement with the recycling groups that clearly states how the profits from selling recyclable or composted materials will be shared. Governments also need to determine if the compost will be available for free or packaged for sale to farmers and other groups.

DEFINITIONS

Composting: The controlled aerobic biological decomposition of organic material in the presence of air and water to form humus.

Humus: A soil-like material resulting from the partial decomposition of plant and animal matter.

Landfill: Disposal site for nonhazardous solid wastes. The waste is spread into layers, compacted to reduce its volume, and covered by clay or soil, which is applied at the end of each operating day.

Recycling: Collecting, reprocessing, and/or recovering certain waste materials to make new materials or products.

Establishing Efficient Work Areas

When designating a recycling or composting area, the government will need to consider the availability of space and financial resources. Fixed recycling sites may include buildings and mechanized equipment for separating out recyclables. These help to make recycling operations safer and cleaner. They do, however, require a higher capital investment and have increased operational costs because the recyclable materials must be transported from the active area of the landfill to the recycling site. Mobile stations, comprised of compartmentalized push carts, allow recycling groups to move from one disposal site to another. They are a cheaper option, but might decrease the efficiency and safety of the recycling process.

A composting area might simply involve neat piles of organic wastes that are turned over by machine or rotated manually and watered frequently to help speed up the natural breakdown of food and plant waste into a nutrient-rich compost. Watering also reduces the potential for material to be moved by wind. Formal composting activities might include the use of "windrows," organized rows of organic material that can be rotated manually or with machines. Some governments may also find it useful to purchase a machine to shred fallen trees and landscape trimmings. Regardless of how complex the composting activities are, it is important to monitor the organic breakdown of materials in order to control odors, keep rodents out, and ensure a useful end product.

The success of these recycling and composting activities may affect other components of the integrated solid waste management (ISWM) system. Keeping track of materials diverted from disposal will be useful to local governments considering new recycling programs or construction of transfer stations, combustors, and landfills to manage solid waste.

CASE STUDY

COOPERATIVE RECYCLING IN BRAZIL

Businesses in Brazil are taking a lead role in organizing recycling collection in the country's major cities. In 1992, private companies from various sectors established the Brazilian Business Commitment for Recycling (CEMPRE), a nonprofit organization dedicated to the promotion of recycling within the scope of integrated waste management. CEMPRE tries to increase the community's awareness of recycling and other solid waste issues through publications, technical research, seminars, and databases. The outreach programs are aimed at those who influence public opinion, such as mayors, directors of companies, academics, and nongovernmental organizations (NGOs). The training programs support the development of recycling cooperatives.

Organizing scavenging or wastepicking activities into recycling cooperatives has been one of CEMPRE's main activities. The official curbside recycling program in the city of Curitiba, for example, collects 800 tons of recyclables a month at a cost of $180 per ton, while local catadores (scavengers or wastepickers) collect over 3,000 tons a month at no direct cost to the city. In organizing informal recycling activities, CEMPRE hopes to better the catadores' position in Brazilian society, increase the national recycling rate, and create economies of scale. According to CEMPRE, the catadores' free market approach is more economical than Brazil's government-run curbside collection programs, and cooperatives enable members to sell to larger dealers at higher prices. The few cooperatives that already exist have demonstrated great success. In São Paulo, for example, members of a cooperative receive 40 percent more money than they would have earned on their own. To inform the catadores about the benefits and logistics of organizing into recycling cooperatives, CEMPRE distributes educational material throughout Brazil and holds courses on the materials. Catadores attended 10 classes, learning about topics from health care for workers to the basics of running a cooperative. In addition, the class visited Belo Horizonte's composting plant and properly designed, constructed, and managed landfill to learn more about the city's solid waste services. CEMPRE has completed many other projects to promote recycling in Brazil, including developing a series of recycling handbooks. CEMPRE also has sponsored a database of solid waste documents, worked to standardize packaging symbols, and conducted studies of local recycling programs. The organization also developed a decision-makers' guide to solid waste management in Brazil and distributed it to every mayor in the country. For more information on CEMPRE, visit the organization's Web site at: <www.cempre.org.br>.

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What Are the Options For Waste Disposal?

Many cities have no controlled system for waste disposal. Waste is either burned in pits, dumped in random locations, or disposed of in uncontrolled dumps without any further management. All these actions harm public health and the environment. Controlled waste disposal can help improve and protect the health of local populations and preserve valuable environmental resources, such as groundwater and drinking water. You have two options for waste disposal: operate a properly designed, constructed, and managed landfill or burn the waste in a controlled facility that converts waste to energy. This fact sheet describes the dangers of open dumping and burning and explains procedures for proper landfill disposal and controlled burning. At the end of this fact sheet is an example of how using one of these options benefitted the Gaza Strip.

What Problems Can Uncontrolled Dumping and Burning Cause?

Most uncontrolled dumps are many years old, having grown over time from small dumps to large, unmanaged waste sites. Uncontrolled dumps have significant environmental impacts. As the waste decomposes, it creates leachate—a mix of toxic and nontoxic liquids and rainwater—which may get into local water supplies and contaminate the drinking water. Uncontrolled dumps also release gases that are explosive and flammable. In some instances, waste is burned at these dumps, which poses a direct safety threat because of the danger of explosion. The air pollution created by burning harms local communities. Improper waste disposal also produces greenhouse gases (GHGs), which contribute to climate change. In contrast, properly designed, constructed, and managed landfills aim to prevent or minimize health and environmental impacts. They have liners and leachate collection systems that protect groundwater, and gas collection systems that contain or safely burn methane from landfills.

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Properly Designed, Constructed, and Managed Landfills

To protect human health and the environment, communities should discourage the use of existing open dumps and establish a managed site for solid waste disposal. Safe, well-controlled waste placement distinguishes a landfill from an open dump. If you want to provide a properly designed, constructed, and managed landfill in your community, you can either convert an existing uncontrolled dump or construct a new landfill.

Converting Existing Open Dumps to Properly Designed, Constructed, and Managed Landfills

Existing open dumps can be converted to landfills in three phases:

Phase 1: Convert open dumps to controlled dumps. The steps involved in this phase include: (1) covering exposed wastes with soil, sand, or clay; (2) installing passive gas vents to safely control methane emissions; (3) establishing rules for onsite scavenging or wastepicking; and (4) organizing wastepickers into recycling groups.

Phase 2: Convert controlled dumps to simple landfills During this phase, basic engineering techniques are gradually employed to stabilize the waste and control environmental releases. The waste is spread and compacted in layers and leachate is collected. At this point, scavenging or wastepicking activities should be confined to areas of the landfill away from compaction areas and heavy equipment.

Phase 3: Transition from simple landfills to properly designed, constructed, and managed landfills. Activities during this phase include: (1) developing formal engineering designs; (2) providing daily onsite management by trained workers; (3) placing waste in small working areas with daily cover; (4) collecting and burning landfill gas; and (5) installing liners and piping to collect and treat leachate.

Establishing a New Properly Designed, Constructed, and Managed Landfill

The process of developing a properly designed, constructed, and managed landfill can be divided into four steps:

Step 1: Selecting the site. Several factors should be considered when selecting a site for a landfill:

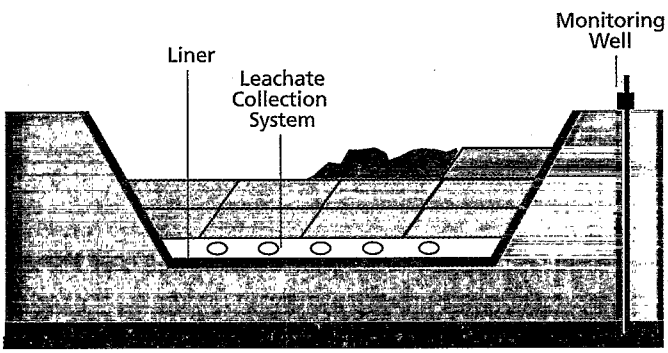
- **Geological factors.** Landfills produce leachate when waste is exposed to rainwater while it is decomposing. If leachate leaks out of the landfill, it can contaminate groundwater and drinking water. To protect local water supplies, the site must have a geology that naturally prevents or limits the release of leachate to the environment. For example, locating the landfill in an area with clay soils—through which water cannot flow—will provide this protection.
- **Distance to the location of the waste.** The farther a landfill site is from the point where the waste is generated and collected, the more waste transport costs. It is generally most cost-effective to use a site a relatively short distance away.
- **Landfill capacity.** Determine how many years the landfill will be able to accept waste. Calculate the volume (or capacity) of the landfill by using the following factors: amount of waste generated per person per year, population size, anticipated population and economic growth, and the number of years the landfill will be in operation.
- **Areas to avoid.** Landfills should not be located near airports, schools, drinking water sources, or flood-prone areas.

Step 2: Gaining public acceptance. Residents who live near the chosen landfill site may have concerns about its environmental and health impacts. You can increase public acceptance by educating local residents and business owners about how the landfill will benefit the community (e.g., by improving public health and safety, creating local jobs, and stimulating economic development). You also can describe what steps will be taken to protect public health and the environment.

Step 3: Designing the landfill. Design requirements for a properly designed, constructed, and managed landfill include the following (see Figure 1):

- **Liners.** Liners are used to prevent leachate from entering groundwater by keeping fluids within the landfill area. Liners must be made of relatively impermeable material such as compacted soil or clay, synthetic materials (e.g., plastic), or a composite of earthen and synthetic materials. They are placed in the bottom of a new landfill before disposing of any waste. Liners are important for landfills located on sandy or other soils through which water can easily flow.
- **Leachate collection and treatment.** In a properly lined landfill, leachate accumulates within the landfill. Therefore, the landfill should include equipment to collect and divert the leachate from the landfill and treat it. Perforated piping, for example, can be installed to collect the leachate and divert it to a nearby treatment facility (similar to a water treatment facility). Treated leachate can then be safely released to the environment.
- **Gas collection and treatment.** Bacteria that are naturally present in landfills produce methane as they decompose and break down the waste. Methane poses a danger because it is explosive and can start fires. In addition, methane from landfills and other sources is harmful to the atmosphere and climate because it is a greenhouse gas. Therefore, monitoring the amount of and controlling methane is very important. Typically, a system is installed to monitor, collect, and burn the gas. In some instances, power stations can collect the gas and use it to generate electricity.

Figure 1—Cross-Section of a Typical, Properly Designed, Constructed, and Maintained Landfill



- **Site access.** Access to the landfill must be strictly controlled to prevent injury or illegal dumping. This can be done by building a fence around the site.

Step 4: Operating the landfill. A trained landfill manager should be hired to properly operate and manage the site. Before any waste is disposed of, the manager should develop a plan to serve as the operational guide for the site. It should specify, in detail, where on the site waste is to be placed, how the site will be operated, at what points the garbage will be covered by soil, and how environmental problems (e.g., animals, litter, fires, gas, leachate) will be addressed. The plan also should provide details of equipment, materials, and staff needed to operate the site; list the environmental agency's required monitoring and reporting activities; and clearly describe when and how each part of the site will be covered and maintained once it has reached its capacity.

Burning Waste in a Controlled Facility

Combustion, or the controlled burning of waste at high temperatures to produce steam and ash, is another waste disposal option and an alternative to landfilling. Waste combustion reduces the volume of solid waste to be disposed of by approximately 90 percent. This is especially attractive in crowded cities that do not have enough land available for landfills. In addition, solid waste can provide a continuously available source for generating energy through combustion. When steam-driven turbines convert the thermal energy from combustion into electrical energy, the process is called "waste-to-energy" (WTE). Steam or hot water produced during combustion also may be sold directly for industrial processes or space heating, or it may be used to generate chilled water for air conditioning. Selling the recovered energy or water in one of these forms helps offset the high costs of construction and operation of waste combustion facilities, but it does not cover them entirely.

Waste combustion, however, has significant disadvantages. Constructing a WTE facility requires large amounts of money. The combustion process also creates air pollution, ash, and waste water, all of which must be properly managed using technical monitoring, containment, and treatment systems. If these byproducts are not controlled, harmful pollutants will be released into the environment. Operators of these facilities must be well-trained and certified to ensure proper management. You must also find disposal options for waste that cannot be burned.

CASE STUDY

CONVERTING OPEN DUMPS INTO PROPERLY DESIGNED, CONSTRUCTED, AND MANAGED LANDFILLS IN GAZA

The German Agency for Technical Cooperation (GTZ) recently assisted the Solid Waste Management Council of the Gaza Strip in closing down a number of open dumps and building a properly designed, constructed, and managed landfill. The first step in constructing a landfill was to assess soil and groundwater conditions at several potential locations. Two important site selection criteria were soil with enough clay content to serve as a natural barrier to leachate and a site away from major drinking water sources. Once the team found a site, it hired local contractors to prepare the landfill site and cover the surface with an asphalt liner. It then built a storage pond and installed drainage pipes that carry leachate into the pond. Since Gaza has no municipal wastewater treatment facilities to treat the leachate, the team installed pumps and a sprinkler system that recirculates the leachate back to the landfill, allowing it to evaporate. The team considered recirculation to be a reasonable option because it did not expect the region's dry climate to generate much leachate and anticipated most of the leachate would be managed through evaporation. However, the storage pond and pumping system were later enlarged to handle larger-than-expected leachate levels.

Once the landfill was in operation, they closed the open dumps, controlled access to the new site and began transfer of waste into the new landfill. The team expects the landfill to last for approximately 13 years. As the team closes filled sections of the landfill, it covers the area with compost generated from digging up and screening organic material from older sections of the landfill. The compost serves as a cost-effective final cover that helps break down the methane as it leaves the landfill surface. The compost also supports vegetation that grows on the landfill surface, which helps reduce the flow of leachate. The project is a successful example of an upgrade of disposal standards. For more information on the Gaza landfill project, visit the Swiss Agency for Development and Cooperation Web site at <www.skat.ch/ud/swm/swm.htm>.

DEFINITIONS

Combustion: Refers to controlled burning of waste to reduce waste volume and perhaps to generate energy.

Impermeable: The property of a material or soil that does not allow the movement or passage of water.

Leachate: A mix of toxic and nontoxic liquids and rainwater created in the landfill environment that may pose a threat to local ground-water supplies.

Methane: Also called natural gas, methane is generated when waste in a landfill decomposes. It makes up approximately 50 percent of the gases emitted from landfills.

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What Are the Components of Waste Collection and Transport?

Existing waste collection and transport systems often cannot handle the amount of waste generated by large cities with growing populations. When this occurs, waste is disposed of in uncontrolled dumps or openly burned. This type of unmonitored and uncontrolled waste disposal has negative consequences on human health and the environment. Improvements to waste collection and transport can create jobs, decrease open dumping and burning, increase appeal for tourism, and significantly improve public health. This fact sheet provides basic guidelines for planning waste collection and transport activities in cities. These guidelines support an ongoing process of improvements to waste practices through integrated solid waste management (ISWM). A case study at the end of this fact sheet shows how a community in Egypt benefitted from implementing some of these guidelines.

What Are Some Guidelines for Planning Waste Collection and Transport?

Careful planning is critical to utilizing resources efficiently and effectively. The plan should consider factors such as applicable laws and regulations; whether a local or regional approach is most appropriate; available resources and costs; the types, amounts, and locations of waste to be collected and transported; and public acceptance of these activities. The following guidelines can be selectively considered during the planning process for waste collection and transport.

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- **Review existing laws or regulations on waste collection, transport, and disposal.** When designing a waste system, you should determine whether existing national, state, provincial, regional, or local regulations provide adequate legal authority to establish a waste collection, transport, and disposal system. For example, the regulations may specify vehicle types and sizes that can be used for collection, road use limitations (what vehicles may travel on what roads and during what hours), and waste transport safety requirements to reduce the potential harm and exposure to the public. If no such requirements exist in current regulations, the national government may want to rewrite the regulation or address these issues in a national policy and/or decree.

- **Designate one agency to oversee waste collection, transport, and disposal.** The local government should make one agency responsible for waste collection, transport, and disposal. Having a single agency for this task will help eliminate potential overlap and confusion among various government agencies.

- **Determine geographic scope of collection and transport services.** Several local governments may consider combining resources to create a regional collection and transport authority. This alternative is usually more cost-effective and may also reduce the need to site several disposal facilities. If a regional authority approach is selected, communities need to agree on an overall budget and source of funding, then determine how much funding each community will contribute to the program. Many communities also have found they can decrease the cost and improve the quality of service by using private waste collection and transport companies and even cooperatives or micro-enterprises, rather than providing this service themselves.

- **Determine funding, equipment, and labor needs.** After the agency has been selected, you should determine how much labor, equipment, and money to dedicate toward managing waste collection and transport. This decision should be based on at least a basic knowledge of the types and amounts of waste, as well as distances traveled to the waste disposal site. Table 1 lists the advantages and disadvantages of various collection and transport methods. Note that city and rural communities have very different waste collection and transport needs. In rural areas, for example, the most economical method may be manual collection from communal bins. In city areas with established roads, trucks may be used. Enclosed trash containers should be used whenever possible to reduce infestation by insects and rodents. Other factors to consider include vehicle maintenance, frequency of collection, cost of labor, and potential revenues.

Types of Solid Waste Customers

Potential customers may include public housing, private residences, factories or other industrial facilities, construction and demolition sites, office buildings and commercial establishments, and large public institutions such as universities, hospitals, and prisons. In most countries, solid waste generated by a private business is paid for by the company.

- **Determine the type and amount of waste to be processed.** You should identify the types of customers that will be served (see box above). You then need to determine how much waste these customers currently generate, and estimate how much they expect to generate in the future. Future generation rates can be determined by multiplying the following factors: amount of waste generated per person per year, population size, anticipated population growth, and the

number of years the landfill will be in operation. Finally, you should determine what types of wastes are generated—household wastes, bulky items, or construction and demolition wastes. Note that waste composition may vary with climate, type of customer served, and the region's economy (e.g., more plant or vegetation waste may be generated during the growing season). This factor is especially important in tourist or resort areas, where the number of people and the amounts of waste tend to change frequently.

- **Consider a transfer station.** Facilities where waste is transferred from manual or small collection vehicles to larger vehicles before being transported to disposal sites or landfills are called transfer stations. Transfer stations are necessary when disposal sites are located far from the collection areas, or when several communities contribute to the same landfill or waste facility. Transfer stations can also serve as a central location for activities to sort and recover waste.
- **Involve the public.** To address the needs of the community, obtain and consider public input throughout the planning and decision-making process. Obtaining public input also offers opportunities to educate the community about proper waste collection, storage, and disposal. This will help ensure an effective solid waste management system.

Table 1—Waste Collection and Transport Methods

METHOD	ADVANTAGES	DISADVANTAGES
Trucks	■ Carry large loads. ■ Appropriate for hauling over long distances typical in rural areas. ■ Require few workers.	■ Have moderate maintenance costs. ■ Require established roadways.
Trains	■ Carry large loads. ■ Appropriate for transporting waste long distances.	■ Expensive to operate and maintain. ■ Railroad proximity to customers a must.
Barges	■ Carry large loads. ■ Appropriate for transport between coastal communities or on large rivers.	■ Expensive to operate and maintain. ■ Not appropriate for land transport. ■ Must be used in combination with other transport methods.
Transfer stations	■ Serve as an intermediate collection point for small-scale waste haulers (e.g., carts). ■ Appropriate for urban areas where disposal is located far away. ■ Can further support the secondary materials markets (i.e., recycling).	■ Require a dedicated site, maintenance, and site management. ■ May have public opposition due to odors, increased traffic, and illegal dumping and/or open burning.

CASE STUDY

IMPROVED WASTE COLLECTION IN BARDEES, EGYPT

As part of a regional environmental action plan developed by Support for Environmental Assessment and Management (SEAM), a task force consisting of the Egyptian Environmental Affairs Agency and a British consulting firm, communities throughout parts of Egypt were surveyed on environmental issues. In Bardees, a city of 40,000, residents identified waste management as its most important environmental problem.

SEAM worked with local organizations in Bardees to get more detailed opinions from both residents and waste collection workers. Many residents were concerned about inadequate coverage of collection services and the general dirty appearance of city streets. The city's equipment was in poor condition and held a limited amount of waste, which often spilled onto the streets. Collection was inconsistent and incomplete, with 90 percent of residents in smaller streets often not receiving any service. Through community focus groups, SEAM found that approximately 68 percent of residents were willing to pay for improved services. Waste collection workers were consulted to identify disposal patterns and collection needs. SEAM and the local government council also researched the community's existing waste stream and waste management practices. They determined common waste disposal practices and preferred ways to collect waste. The city was collecting trash using tractors attached to trailers that could hold only 2.5 cubic meters (m^3) of waste, and some residents were paying donkey-cart operators to collect their waste.

DEFINITIONS

Nonbiodegradable: Not capable of decomposing under natural conditions.

Regulation: A rule or ordinance by which conduct is regulated or that establishes certain standards or requirements for activities or operations.

Source Separated: Separating various wastes at the point of generation (e.g., separation of paper, metal, and glass from other wastes) to make recycling simpler and more efficient.

Transfer Station: Facility where solid waste is moved from collection vehicles to other vehicles for transport to materials recovery or disposal sites.

To improve collection services, SEAM developed a trailer that could accommodate up to 7 m^3 of waste. SEAM helped the city modify its old trailers and saved them for use in outlying areas and emergencies. The city purchased hand carts for collection from narrow streets, set schedules for morning collection, and gave uniforms to the staff of 17 sweepers. To educate residents and gain their participation, SEAM and the local government council worked with three local religious organizations to coordinate community awareness activities. One organization, for example, reached out to women through its literacy classes, sewing center, and daycare center. Another organization distributed leaflets to shops urging them to put their waste in garbage bins.

With its residents involved and understanding their role in keeping the community clean, Bardees has successfully improved its collection services and cleaned up its streets. While the city is currently paying all the operating costs for waste collection, it is working with an NGO to start collecting user fees from residents and businesses. For more information on SEAM's waste management activities, visit <www.seamegypt.com>.

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